

ALTERNATIVE FUEL VEHICLES

The Emerging Emissions Picture

Interim Results — Summer 1996



The work described here is part of an ongoing program sponsored by the U.S. Department of Energy (DOE), and managed by the National Renewable Energy Laboratory (NREL), a DOE national laboratory. NREL is cooperating with the U.S. General Services Administration, West Virginia University (WVU), fleet operators, and several private laboratories to perform this work.

Light-Duty Vehicles: Cars, Trucks, and Vans

Program Goal:

To provide a high-quality, objective evaluation of in-use emissions from commercially available alternative fuel vehicles.

Program Description

Vehicles from the U.S. Federal fleet are randomly selected and delivered to private emissions test facilities in this statistically designed program. The testing is performed on a chassis dynamometer according to Federal Test Procedures for emissions certification. These procedures include exhaust and evaporative emissions. Additional detail is obtained by performing hydrocarbon speciation on the emissions.



On a chassis dynamometer, the wheels of a test vehicle are supported by rollers that simulate driving conditions, while the driver follows a test cycle. Laboratory instruments measure fuel economy and regulated emissions.

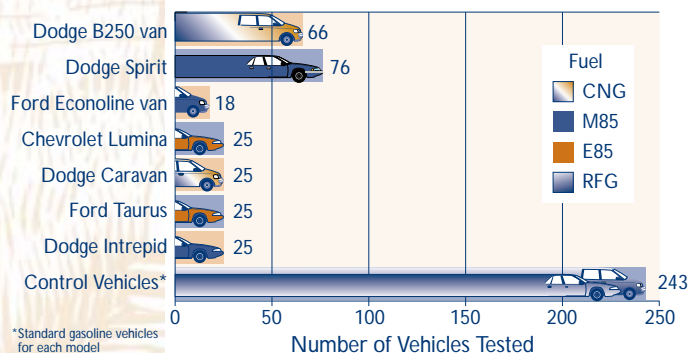
Hydrocarbon speciation is the most comprehensive type of analysis run on emissions. In this analysis, hundreds of hydrocarbon compounds found in vehicle emissions are quantified. These results are used to study the toxicity and ozone-forming potential (ozone contributes to photochemical smog in the atmosphere) of the vehicle exhaust.



Vehicles/Fuels Tested

Laboratory staff have tested a wide variety of original equipment manufacturer alternative fuel vehicle models, and a limited sample of aftermarket conversions. The vehicles have been tested on methanol (M85, 85% methanol and 15% gasoline), ethanol (E85, 85% ethanol and 15% gasoline) compressed natural gas (CNG), propane, and reformulated gasoline (RFG).

Fuels, Vehicle Models, and Number of Vehicles Tested



To stay current with the changing marketplace, testing of the latest qualified vehicle modifier (QVM) CNG and liquefied petroleum gas (LPG) vehicles has been scheduled.

Selected Results

When engineered and maintained properly, alternative fuel vehicles have shown the potential to significantly reduce overall emissions. Sample results from the first round of testing are shown below.

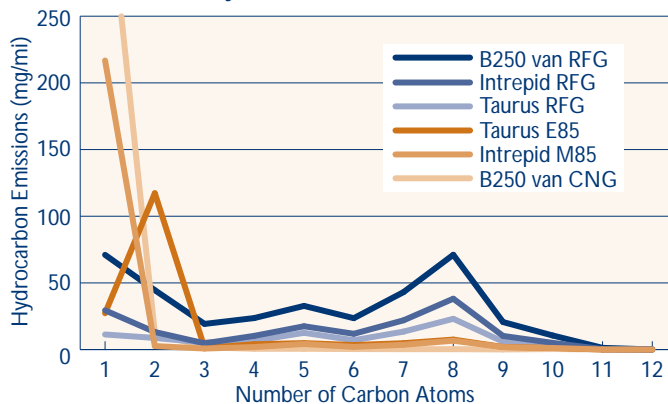
Selected Early Results

Models and Fuel	Early Exhaust Emissions Results Compared to RFG
CNG Dodge B250 van	30% – 80% reduction in NO _x , CO, and NMHC. 75% reduction in ozone-forming potential.
M85 Dodge Spirit	Modest reductions in NMHC and CO. 40% reduction in ozone-forming potential. Small increase in NO _x .
M85 Ford Econoline van	Modest reductions in NMHC and CO. 50% reduction in ozone-forming potential. Small increase in NO _x .
E85 Chevrolet Lumina	Approximately 20% reductions in NMHC, CO, and NO _x . 25% reduction in ozone-forming potential.

NO _x	Oxides of nitrogen
CO	Carbon monoxide
NMHC	Nonmethane hydrocarbons

Hydrocarbon emissions profiles were very different from fuel to fuel. Highly toxic compounds such as benzene and 1,3-butadiene were much lower from the alternative fuels, but the alcohol fuels had increased aldehyde emissions. Hydrocarbon emissions from CNG vehicles were primarily methane. Also, the hydrocarbon compounds from the alternative fuels had consistently lower ozone-forming potential than reformulated gasoline.

Hydrocarbon Emission Profile



Emissions results from CNG and LPG aftermarket conversions were not as promising as the original equipment manufacturer's models. This highlights the need to consider both the fuel and the vehicle technology when evaluating options for reducing air pollution.

Heavy-Duty Vehicles: Trucks and Buses

Program Goal:

To compare the in-use emissions from trucks and buses equipped with the latest certified alternative fuel engines to those from their diesel counterparts.

Program Description

To test the heavy vehicles, West Virginia University (WVU) designed and constructed a transportable chassis dynamometer with DOE funding. The ability to transport this unit from site to site allows a large number of in-use emissions tests to be conducted in cities around the country.

Vehicles/Fuels Tested

Under NREL evaluation programs, WVU has tested more than 75 alternative fuel transit buses and trucks. Vehicles were tested on ethanol (E95, or 95% ethanol and 5% gasoline), methanol (M100, or neat methanol), CNG, liquefied natural gas (LNG), and biodiesel blends. At each site, closely matched diesel control vehicles were also tested for comparison. The testing has concentrated on widely used alternative fuel engine models, including the Cummins' L10 CNG engine and Detroit Diesel Corporations's 6V92 alcohol engines.

Description of Heavy Vehicles Tested

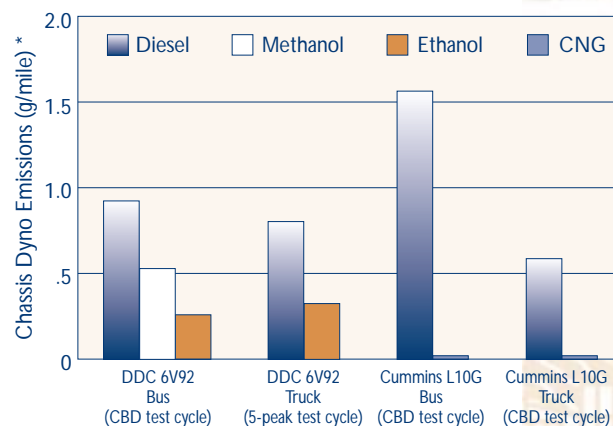
Engine Make	Engine Model	Fuel System	Test Site	Vehicle Type
Cummins	L10	CNG	NYC	Garbage Trucks/ Buses
			Miami, FL	Transit Buses
		LNG	Tacoma, WA	Transit Buses
			Portland, OR	Transit Buses
Detroit Diesel	6V92	Ethanol	Sheldon, IA	Line-Haul Trucks
			Peoria, IL	Line-Haul Trucks/Buses
		Methanol	Minneapolis, MN	Snowplows/ Buses
			Miami, FL	Transit Buses
	Series 60	BD20	St. Louis, MO	Transit Buses
		CNG	NYC	Garbage Trucks
		BD35	Sheldon, IA	Line-Haul Trucks
		BD35	Sheldon, IA	Line-Haul Trucks
Caterpillar	3306	BD35	Sheldon, IA	Line-Haul Trucks

Alternative fuel heavy vehicle engine technology is evolving rapidly. Several engine manufacturers are releasing new alternative fuel models or enhanced versions of the older engines. Testing and evaluation of these latest engines is a high priority for the program.

Selected Results

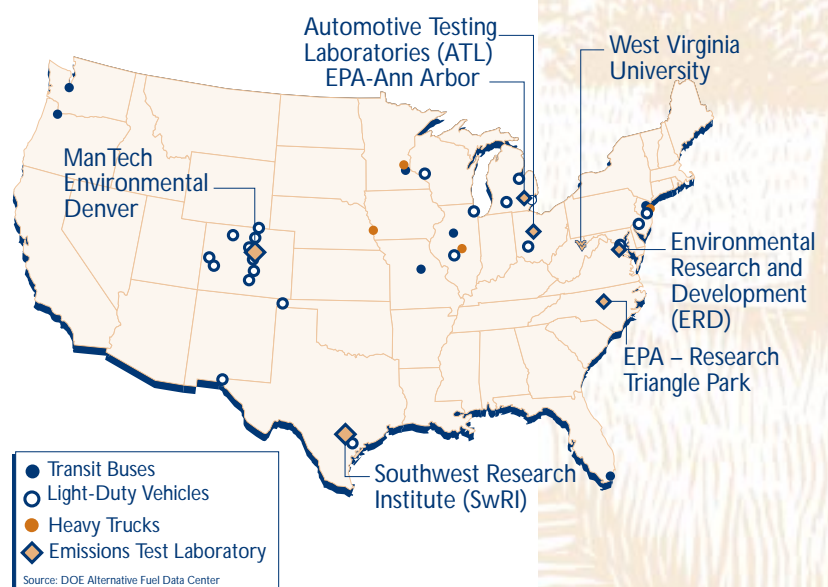
Particulate matter is a serious health concern in urban areas and NO_x contributes to ozone formation in the atmosphere. In-use test results from this program have shown that alternative fuels generally have lower particulate matter and NO_x levels than their diesel counterparts. Some selected results are shown below.

Particulate Matter Emissions Results



* Note: Results reported here are from chassis dynamometer testing. Heavy-duty engines are certified for emissions using engine dynamometer test procedures.

Emissions Testing Locations



Additional Research and Further Information

NREL Research and Development (R&D) Program

NREL also manages an extensive alternative fuels R&D program for DOE. This program has two main elements:

Engine optimization...research designed to increase the viability and utilization of alternative fuels by developing alternative fuel vehicle technology that is superior in performance to conventional fuel vehicles

Atmospheric reactions...research designed to increase our understanding of the potential atmospheric impacts of alternative transportation fuel use.

A number of these R&D projects involve evaluation or development of technologies for improved emissions.

For More Information

The Alternative Fuels Data Center is a mouse click or a phone call away:

Our World Wide Web site address is
<http://www.afdc.doe.gov>
(800) 423-1DOE

NREL maintains the center on the World Wide Web, which is accessed more than 40,000 times per month by up to 4,000 individuals. The Web site contains a wealth of information on alternative fuel vehicle emissions: emissions data, program summaries, reports and presentations that can be downloaded, citations on related efforts, links to other sources, and much more. The center has become the nation's best-known and most comprehensive source of alternative fuels information. To talk to a human being, call (800) 423-1DOE.

Selected Publications Available From NREL

- *Alternative Fuel Transit Buses: Final Results from the National Renewable Energy Laboratory Vehicle Evaluation Program*, October 1996
- *Compressed Natural Gas and Liquefied Petroleum Gas Conversions: The National Renewable Energy Laboratory's Experience*, April 1996
- *Alternative Fuel Light-Duty Vehicles: Summary of Results from the National Renewable Energy Laboratory's Vehicle Evaluation Data Collection Efforts*, May 1996
- "FTP Emissions Test Results from Flexible-Fuel Methanol Dodge Spirits and Ford Econoline Vans," Society of Automotive Engineers, Inc. (SAE) paper number 961090
- "Round 1 Emissions Test Results from Compressed Natural Gas Vans and Gasoline Controls Operating in the U.S. Federal Fleet," SAE paper number 961091
- "Federal Test Procedure Emissions Test Results from Ethanol Variable-Fuel Vehicle Chevrolet Lumina," SAE paper number 961092
- *Alternative Fuel Trucks Case Studies: Running Refuse Haulers on Compressed Natural Gas, and Running Line-Haul Trucks on Ethanol*, October 1996



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